BULLETIN 505 AUGUST, 1932

Factors Influencing the Dressing Percentage of Hogs

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AGRICULTURAL EXPERIMENT STATION
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ACKNOWLEDGMENTS

This study has been made possible by the cooperation of all agencies involved. Particularly is this true of the different slaughtering companies who obtained the individual, dressed carcass weights by tattooed marks, along with other information, and forwarded them to the writers for analysis.

In starting the study it was necessary to travel extensively out of the State. The Federal Farm Board furnished the necessary funds for this expense; otherwise, in all probability, the study could not have been started. In addition, the Federal Farm Board, through Mr. C. G. Randell, assisted in interesting the eastern packers in cooperating in the project. Aid was also given in outlining the plan and procedure of the study.

Officers and managers of the cooperative livestock associations have assisted greatly in one phase or another, at some time, during the study.

Ohio Agricultural Experiment Station
and
Federal Farm Board
Division of Livestock Marketing
Cooperating

FACTORS INFLUENCING THE DRESSING PERCENTAGE OF HOGS

G. F. HENNING AND W. B. STOUT

INTRODUCTION[1]

Although the direct-to-packer marketing of hogs is not a new institution, it has been only during the past decade that marketing hogs direct, cooperatively[2], has become important in Ohio. This method of marketing hogs in Ohio took form in 1923 when the Eastern States Company, now the National Order Buying Company, was organized with offices in Columbus, and, together with the Fayette County Producers' Association operating at Washington Court House, Ohio, commenced to sell hogs direct to slaughterers.

Along with the development of this method of marketing by cooperatives, many problems presented themselves. Packers at first were asked to buy a product from organizations with whom they had had no previous business experience, and they were also asked to buy a product which they had never seen and would not see until it was delivered to their plant. Consequently, some kind of an understanding and working relationship had to be agreed upon in order that buyers would have some idea of their purchases before delivery. These difficulties were overcome, to some extent, by shipping association managers grading the hogs very closely for weight, quality, and finish and bargaining from day to day on carload purchases.

This arrangement did not satisfy all parties involved. Shipping association managers were selling hogs on the basis of liveweight. This has been, and still is, the common practice in selling hogs. However, packers supply the retailers, who, in turn, sell meat to the consumers. It is the amount and quality of the meat which is consumed at different prices, reflected through the packer, that determine primarily the value of the hog. Consequently, it is the dressed carcass of the hog which is of major importance to the packer. But, inasmuch as the cooperative associations were selling hogs on a liveweight basis, they were confronted by the problem of

[1]The writers are especially indebted to C. W. Hammans, marketing specialist of the Extension Service, the Ohio State University, who assisted in planning the project and interviewing the different parties interested in the study and who assisted in directing the project during the early stages of its development.

[2]For a full description of cooperative marketing, direct to packers, see *The Cooperative Marketing of Livestock* by E. G. Nourse and Joseph K. Knapp.

the variation in the ratio or relationship of the dressed carcass to the liveweight. This ratio is known as the "dressing percentage" and is more commonly called "yield".

The dressing percentage is of more importance than many realize; for example, one carload of 25,000 pounds of hogs, liveweight, might yield 19,500 pounds of dressed carcasses in the coolers of a slaughterer. This would give a dressing percentage of 78 per cent. Another carload of 25,000 pounds, liveweight, might yield only 18,500 pounds of dressed weight, giving a dressing percentage of 74 per cent. This difference of 1000 pounds in dressed weight between the two carloads becomes important, since the slaughterer, in turn, can sell 1000 pounds more meat to the retailer. Thus, the first carload is worth more to the slaughterer and, in turn, to the livestock producers.

A few livestock marketing agencies and several slaughterers have recognized this problem in marketing hogs and have attempted to get at a better basis of settlement in the marketing process than that of liveweight. They have agreed upon dressed weight as a basis for settlement, although price determination is made on the basis of liveweight.

In order that the marketing agencies may operate on a workable plan, a guaranteed dressing percentage for settlement is agreed upon, in advance, for a definite period. This means, more specifically, that a carload of hogs is sold to yield a definite weight of dressed carcasses. A carload of hogs when slaughtered, may yield exactly the guaranteed dressing percentage, or it may yield less or even more than this amount. If less, the carload is said to underdress and, if more, to overdress. When the carload yields an overdress, the slaughterer[3] pays for the overdress, but, when it yields an underdress, the producer bears the loss.

This basis of settlement recognizes the dressing percentage with its many problems, the most important of which is the variation in the dressing percentage between different carloads. There is a great variation in yield from different counties, from the same counties, from the same shipping point, and from the same producers on the same day, as well as on different days. This variation has been of considerable concern to marketing agencies selling on a basis of yield, especially when carloads underdress. It was because of the problems arising from the variation in the yield of different carloads that this study was carried out.

[3]In some instances slaughterers do not pay for an overdress but deduct for underdress. This depends upon the previously arranged plan of sale.

It became more and more important to know and to understand the factors which influence the yield. To this end the Ohio Agricultural Experiment Station, the Ohio State University, the National Order Buying Company, the Federal Farm Board, a number of Eastern and Ohio meat packers, and seven county livestock cooperative associations in Ohio have cooperated in outlining and collecting the information upon which this study is based.[4]

Information was collected mainly from three different sources. The managers of the various associations cooperating in the study were asked to tattoo the hogs from each individual producer, in order that the identity of carcasses might be maintained by each farmer furnishing hogs. Thus, it was possible to obtain information pertaining to the handling practices of individual lots of tattooed hogs at the local shipping point. Packers also were asked for information on such matters as the time of arrival and the weight upon arrival, the time of slaughter, the individual carcass weights according to tattoo numbers, and the condition of the carcasses. By maintaining the identity of the hogs by the use of the tattoo iron, it was possible to obtain individual producer's yields throughout and to make direct comparisons between the yield and many other factors. Producers who marketed the hogs studied were asked to fill out questionnaires on the feeding, management, and breeding practices of their individual lots of hogs delivered to the association.

In addition to these data on tattooed hogs, other information was secured from the National Order Buying Company on 437 carloads. Data on Federal Inspected Slaughter secured from *Crops and Markets*, published by the United States Department of Agriculture, were also used.

The records obtained on the tattooed hogs were secured from seven different county cooperative associations. The hogs were graded in the usual manner before they were consigned to the packer and handled just the same as any ordinary carload. They were typical of thousands of Ohio hogs marketed direct. Similarly, the records obtained from the National Order Buying Company were of the above type, except that they were limited to one slaughterer, for reasons of uniformity.

[4]Valuable suggestions were offered also by the director of the Research Department of the National Livestock Marketing Association.

INTERPRETATION AND CONCLUSIONS[5]

As explained in the introduction, this study is based on data obtained from three sources; namely, tattooed hogs from seven cooperative associations, records from 437 carloads of hogs shipped by the National Order Buying Company to one slaughterer, and data on Federal Inspected Slaughter for the eight years 1923-1930.

It was the aim throughout to study marketing operations from day to day, just as they occur in hundreds of places where hogs are marketed. It was not intended as an experimental project, where a number of factors are held constant and only one or several are permitted to vary. The factors studied were observed and data were secured, showing the variation from day to day in ordinary commercial operations. The type of study must be kept in mind when studying this analysis.

Contrary to the opinion of most livestock marketing men, production factors had little influence on yield, insofar as we were able to analyze the relationship in this study. Even rations showed very little influence on yield. The high-yielding hogs received a greater percentage of "A" rations (those considered the best) than did the low- or medium-yielding groups, but, when all groups were averaged, the yield from hogs fed "A" or "C" rations was but slightly different. Those fed corn alone gave as high an average yield as the ones fed better combinations.

It would seem that little consideration need be given to rations by marketing agencies attempting to market more high-yielding hogs. This is more easily understood when it is realized that most farmers do not feed the same rations throughout the growing and fattening period. Before the hogs are finally marketed, the farmer may use corn alone, corn with legume pasture, a combination of carbonaceous feeds in a "slop", or numerous other combinations. From this study the writers have concluded that managers can rely but little on the information obtained by asking the farmers at the time of marketing how the hogs were fed during the fattening period. Although rations are not an important factor from the standpoint of yield, this does not mean rations are not important. In fact, there is a mass of evidence which indicates that rations are important in the production of a desirable hog at a low cost of production.

[5]This section is included at this point for the benefit of those readers who do not care to follow through the analysis and the statistical method given in the more detailed parts of the study.

Should an experimental test be carried on for several months with as many factors, except rations, held constant as possible, there is no doubt but that a variation in yield would be found. Some experiments[6] have definitely indicated such results.

Hogs which were given a full feeding previous to shipment did not show quite as high a yield as those given less at the last feeding. The difference was 0.5 per cent. When hogs were not fed for 8 hours or more previous to trucking to the stockyards, the yield was approximately the same as with those fed at the last minute. In marketing hogs on a yield basis it is important to have them "empty" at the time of weighing, having just enough feed to prevent the body tissues from being used to any very great extent before slaughtering. Hogs which were stuffed would undoubtedly give a lower yield, but this is largely a "shrink question".

Other production factors showed no relation to yield, nor did breeds or breeding. It made little difference in yield whether hogs were pure bred, grade, or cross bred, as far as this study was concerned. Even age seemed to have no influence on the yield.

The distance trucked[7] before weighing did not seem to affect the yield or carload shrink. No complete analysis of shrink could be made from individual, producer-owned lots of hogs, because the slaughterers had no way of separating these lots in the different carloads at the packers' yards. Hence, only the carload shrink was available.

However, grading by managers was one of the factors that did have some influence on yield. The group of hogs, high and closely graded, yielded slightly more than the lower-graded ones, although there were many exceptions. It was not uncommon to have hogs graded the same and have a yield-spread of six points—from 72 to 78 per cent for example. In many instances the spread was even greater; so, while grading was a factor, it was evident that there were a number of other variables influencing the yield.

There was a definite seasonal swing in the yield—the low point being reached in the early fall, usually September or October. From this low point there was a steady rise to the high point of January or February, from which the swing was gradually downward during the spring and summer to the low point again in the autumn. Individual years varied but slightly from this average.

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[6]See article in Record of Proceedings of Annual Meeting for 1928 of the American Society of Animal Production by W. L. Robison of the Ohio Agricultural Experiment Station.

[7]See section on Relationship of Marketing Factors to Yield.

The time spent in transit showed little relationship to the yield. Indeed, this factor was fairly uniform in the data studied. A point of more importance was the time intervening between shipment and slaughter. A number of carloads was slaughtered within 4 days after shipment, but some were held until 7 days or more had elapsed. The analysis showed that hogs slaughtered within 5 days from the time of shipment yielded about the same, but, when the time exceeded 5 days, the yield showed a trend downward for each additional day.

Carload shrink was another factor which had an inverse relation to yield and fluctuated greatly. In the special group studied, the shrink fluctuated from less than 6 per cent to more than 12 per cent. With the lower shrink the yield was generally higher; whereas with high shrink the yield was lower. Weight showed some relation to yield; that is, the heavier hogs yielded higher than the lighter ones. However, it was only in the greater spreads in weight that yield was greatly influenced, 25 pounds difference in weight per hog showing comparatively little difference in the yield.

In an examination of Federal Inspected Slaughter it was found that the percentage of lard obtained from the carcass was an important factor influencing the yield. The percentage of barrows slaughtered likewise affected yield. Over a period of 8 years, the corn-hog ratio also seemed to influence yield (Page 26). These three factors, together with liveweight, seemed to account for about 80 per cent of the cyclical swings (the year to year variations) in yield, when the data were measured by a multiple correlation analysis.

It is very evident from this study that hogs marketed by different farmers will vary greatly in the yield. The same is true for different hogs of the same grade marketed by the same farmer. Because of these variations, it is difficult for those in charge of the commercial operations in marketing hogs to keep the yield from varying from carload to carload.

After studying the commercial operations of these seven cooperative livestock associations, it is the conclusion of the writers that the following factors are responsible for the greater part of the variation in yield from carload to carload. They are: (1) The amount of lard which can be obtained from the carcasses, (2) the percentage of barrows slaughtered, (3) the days intervening between time of shipment and slaughter, (4) the amount of shrink, (5) the time hogs are kept from feeding until they are weighed over the scales at the shipping point, (6) the seasonal (month to

month) influence, (7) liveweight, (8) careful grading, and (9) the relative cheapness of corn to pork as shown in the corn-hog ratio. Some of these factors are interrelated; that is, they influence one another. Some are more important than others, but this point will be developed as the different factors are analyzed. Several authorities and some data indicate that the type of hog has considerable influence upon the yield. In this study almost all of the hogs were of the common lard type of country-run hogs found nearly anywhere in the corn belt.

Certain biological characteristics might be responsible for some of the variations. Production factors seem to have less influence than has been assumed by many individuals connected with marketing agencies. Some factors influencing the yield cannot be controlled by the hog farmer, such as time in transit and time intervening between shipment and slaughter. When the farmer is paid on the basis of a carload yield (the average of all hogs in the carload) rather than on the yield of his own hogs, he can influence the yield still less, for he cannot control the percentage of barrows in a car, the amount of lard to be obtained, or the question of shrink.

Since hogs are now marketed on a guaranteed yield by some of the cooperative organizations, the question is raised as to whether or not this is a sound plan of selling. Is this an improvement over the plan of selling on liveweight where the eye judges what the carcass will be? Since yield is influenced directly by the amount of lard obtained from the carcass and since lard in excessive amounts (heavy fat cuts) is not desired at this time by slaughterers, should the yield be used as the basis of settlement? If selling on a guaranteed yield is or is not an improvement over the liveweight basis of settlement, the question is raised as to what should be the real basis of settlement in marketing livestock—and hogs in particular. Should the plan of settlement be carried nearer to the consumer? Should the carcass form the basis of settlement, where the quality of meat, as well as the yield, can be ascertained? Or is the only practical basis of settlement to market hogs as they are and have been marketed for years; that is, on a liveweight basis?

These questions are not in the scope of this study but are of importance to marketing agencies (cooperatives in particular), as well as to slaughterers who are interested in improving methods of marketing.

The following sections present the analysis of this study in detail and form the basis of the conclusions reached by the writers.

THE RELATIONSHIP OF PRODUCTION FACTORS TO YIELD

In the past it has been the opinion of many livestock marketing men that certain production factors, such as the kinds and amount of feed given at the last feeding, the time intervening between the last feeding and shipment, the condition of the animals, and the distance trucked, have had a great influence upon the yield[8] of hogs at the time of slaughter. However, when the data pertaining to these questions were analyzed, it was found that only a slight relationship existed. Neither was there found to be any appreciable relation between yield and any other production factors that were taken into consideration.

The analysis and discussion that follow are based on 11,109 tattooed hogs which represent 790 individual producers' samples. These hogs were all reported in good condition as far as health was concerned. The number driven or hauled to the shipping point in wagons was few. In most instances the tattooed hogs studied were penned in the yards from 3 to 6 hours before loading, very few holdovers being considered in this study. Practically all hogs had access to water at all times, but only a very few had been fed wet feed as the final feeding. With these factors in mind, we shall proceed with the analysis of the data.

After some preliminary study it was decided, for a comparison of different production factors and the yield, to divide the data into three groups (low-, medium-, and high-yielding). Hogs were classified as "low yielding" if they returned a dressing percentage of less than 72.5 per cent, "medium yielding" for a return of 72.6 to 76.0 per cent, and "high yielding" for over 76 per cent.

When these three groups were compared for the influence of age on yield, no relationship was found. The low-yielding hogs averaged 7.7 months in age, the medium-yielding hogs 8.5 months, and the high-yielding hogs 7.8 months.

In attempting to check on the relation between rations fed and the yield of hogs, producers were asked to list the kinds of feed given for both growth and fattening. These rations were then rated and classified by letters.[9]

[8]Throughout this study, yield is defined as the percentage relation between the dressed carcass and the liveweight at the shipping point at the time of delivery from the trucks. All data were adjusted to a comparable basis; namely, warm weight, kidneys in, heads on, etc.

[9]J. W. Wuichet of the Extension Department of the Ohio State University and Paul Gerlaugh and W. L. Robison of the Ohio Agricultural Experiment Station cooperated with the writers in rating the rations. It must be remembered that in making these ratings, only the kinds and not the amounts of feed in each ration were given, and, therefore, the rating could be only approximately correct. In the case of the growing rations, those that were rated 90 per cent or above were designated as "A"; 80 to 90 per cent as "B"; 60 to 80 per cent as "C"; 50 to 60 per cent as "D"; and 50 per cent and below as "E". The fattening rations were divided into three groups because there was less variation in feeds used for fattening. Rations rating 80 per cent or above were called "A", 75.0 per cent to 80 per cent "B", and 75 per cent and below "C".

After sorting the growing rations into these five different groups, the resulting analysis indicated that, during the period of growth, the high-yielding hogs received a somewhat greater percentage of poor rations than did the medium- or low-yielding hogs. The advantage in favor of the "A" and "B" rations was not outstanding, however. When the fattening rations were sorted into the three groups (namely, A rations, B rations, and C rations), the high-yielding hogs again received a higher percentage of A rations than did the low-yielding hogs. However, there was an exception in the medium-yielding group; that is, a higher percentage of medium-yielding hogs received C rations than of the low-yielding hogs.

The growing and fattening rations were subjected to a somewhat different analysis. Each group of hogs receiving the different growing rations was averaged for yield. When this was done, it was found that the growing rations had very little influence on the yield of the hogs; for example, those receiving A rations gave an average yield of 76.8 per cent; those having B rations yielded 76.3 per cent; C rations, 76.1 per cent; D rations, 77.1 per cent; and E rations, 75.9 per cent.

When the fattening rations were averaged on a similar basis, we found that hogs getting the A fattening rations gave an average yield of 77.0 per cent; those receiving B rations, a 75.3 per cent yield; and C rations, 76.9 per cent. Thus, when the influence of growing and fattening rations is considered, the conclusion is reached that feeds given during the growing and fattening periods do not have a very great influence on the yield of hogs. This is shown by the fact that the hogs receiving D growing rations averaged higher than those receiving the A growing rations. On the other hand, in the case of fattening rations, the hogs receiving a C ration yielded nearly as high a return as those receiving an A ration. In fact, the difference was only one-tenth of one per cent in favor of the A ration.

From the standpoint of production and daily gain, feeding experiments have shown that a protein supplement and a variety of well chosen feeds are beneficial in producing rapidly gaining hogs, but in this study we were interested in knowing what influence various combinations of feeds have upon yield. In order to analyze the influence of different combinations, the fattening rations were divided into three groups; namely, corn alone, corn and other carbonaceous feeds, and carbonaceous feeds plus a protein supplement. When this analysis was made, it was found that little variation

existed in the yield of hogs fed these different combinations. In fact, the hogs fed corn alone gave a yield of 75.5 per cent; corn and other carbonaceous feed yielded 75.4 per cent; and corn with a protein supplement, 75.8 per cent. Thus, it is seen that very little advantage from the standpoint of yield can be gained from these different rations. It is also interesting to know that the hogs receiving corn alone numbered 3343; those receiving corn and other carbonaceous feeds, 3131; and those receiving corn with a protein supplement, 4254. This makes a total of 10,728 on which information was obtained.

It would seem, therefore, that rations made little difference in the yield of hogs, insofar as rations could be analyzed in this study. However, it must be remembered that there were many uncontrollable factors involved in this analysis. Should most of these factors be held constant, without a doubt rations[10] would show an influence on yield, especially if fed for some length of time. Some unpublished data of the Ohio Experiment Station indicate such results.

Marketing agencies must of necessity market and buy hogs which have been managed and fed rations that differ nearly as widely as the number of individual farmers furnishing the hogs. Such hogs are truly country-run. It is for this class that a basis of settlement for marketing must be determined upon. As a result of this study, it is believed that the rations fed have little influence on the yield of hogs of the country-run class.

In comparing yield to the amount of the last feeding and the time intervening between that feeding and shipment, we again find very little relation. Full-fed hogs yielded slightly less than those that received a smaller amount at the time of the last feeding. It did not seem to make much difference whether hogs "ran to feed" until the time they were trucked to the shipping yards or whether they were "off feed" a number of hours prior to trucking, Table 1. The probable explanation[11] of this is that hogs fed heavily just prior to trucking would undoubtedly shrink more in transit to the shipping yards than hogs that had been "taken off feed" or had been fed lightly before trucking. This shrink cannot be taken into consideration however, because the liveweights at the shipping points were used in figuring yields.

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[10]See paragraph in the section entitled "Interpretation and Conclusions" for further statement of the writers.

[11]It is also possible that a considerable bias entered into the answering of this question by the farmers. Many may have been reluctant to give the exact facts about the feeding of the hogs prior to shipping. Undoubtedly, many hogs were fed just prior to being trucked to the yards, in spite of the fact that statements to the contrary were given in the schedules.

TABLE 1.—The Relationship of Yield to the Amount of Last Feeding and the Time Interval Between the Last Feeding and Loading into Trucks for Shipment, in the Tattooed Sample

Yield group	Time interval in hours between last feeding and loading									
	Full-fed					Less than full-fed				
	None	1-7.9	8-15.9	16	Average	None	1-7.9	8-15.9	16 and over	Average
Low-yielding	71.5	71.4	71.6	.....	71.5	71.6	71.5	72.4	.....	71.6
Medium-yielding	74.5	74.6	74.7	74.5	74.6	74.6	74.5	74.9	.....	74.6
High-yielding ...	77.6	78.1	78.0	78.0	77.9	78.1	78.6	78.1	.....	78.4

An attempt was made to make a comparable analysis between the carload shrink[12] and the amount and time of the last feeding; but, in so doing, it was necessary to make the assumption that different producers' hogs in the same car shrank the same and that the average shrink of the carload could be used. The results of this comparison showed that the assumption was erroneous and, therefore, the analysis unreliable.

Other production data collected and analyzed in this connection referred to the breeds of hogs marketed (pure bred or grade); the kinds and amounts of minerals fed; whether pigs were treated for worms and, if so, what methods were used; the kinds of feeds given at the time of the last feeding; whether hogs were fattened on pasture range or in dry lot; and whether they were penned or allowed to range just prior to delivery at the shipping yards. The analysis of these factors did not throw any additional light on the relation of production factors and yield.

It may be possible that there is some relation between range and dry-lot fed hogs and the yield. On account of the drouth during the summer of 1930 very little pasture existed in the sections which furnished the hogs analyzed in this study; therefore, our comparison of pasture or range hogs and dry-lot hogs failed to show a fair ratio to yield.

From the data available, it could not be shown that one breed of hogs consistently yielded higher than another. Nor did "blood" seem to make any difference, as the average yield of the grade hogs was approximately the same as the average yield of all pure bred animals.

[12]In this study carload shrink is understood to mean the percentage difference between the liveweight at shipping point at time of delivery from trucks and the liveweight of hogs at time of unloading from the railroad cars into the yards of the slaughterer. It was not possible in this study to obtain the shrink on the different tattooed groups of hogs.

THE RELATIONSHIP OF MARKETING FACTORS TO YIELD

This part of the study will present the data which pertain more especially to the marketing factors and their relation to yield. The factors analyzed under this section are: distance trucked, grading, time in transit, time intervening between shipment and slaughter, and shrink.

When the data were analyzed for distance trucked, the result presented in Table 2 shows that the variation in high-, low-, and medium-yielding hogs cannot be attributed to this factor. There was practically no difference in the distance trucked for the three groups. Another factor affecting the yield and related to the distance trucked is the amount of shrink. The tattooed hogs were divided into three groups—low-, medium-, and high-shrinking[13] carloads. Even though the trucking distances of the various lots of hogs considered varied from less than a mile to over 30 miles, the average distance for the different carloads was approximately the same.

TABLE 2.—The Relationship of Distance Trucked to Yield and Carload Shrink, in the Tattooed Sample

	Yield			Carload shrink		
	Low	Medium	High	Low	Medium	High
Miles trucked	8.4	8.4	8.3	8.6	8.3	8.2

When a frequency distribution was made on the basis of miles trucked, no relation to yield was found. It would seem that hogs trucked greater distances would shrink less and yield more, on the basis of weights taken at the shipping point, than hogs hauled shorter distances. However, the data obtained in this study do not uphold the above assumption.

When shrink was analyzed by age of hogs, it showed that the high carload shrinking group averaged just a little older than the low carload shrinking groups, Table 3; but, when a simple correlation of these factors was run, it was found that the relation was so slight that the apparent trend was probably entirely accidental.

TABLE 3.—The Relationship of Carload Shrink to the Age of Hogs, When Marketed, in the Tattooed Sample

	Shrink		
	Low	Medium	High
Age, in months	7.4	7.5	7.9

[13]Carloads shrinking less than 8 per cent were considered as low-shrinking, 8.0 to 9.9 per cent as medium-shrinking, 10.0 per cent and over as high-shrinking.

The fact that these data had to be analyzed on the basis of carload shrink throws but little light on this phase of the analysis. Had it been possible to obtain the shrink on the respective tattooed groups of hogs, some explanation might have been found for this vexing question. The separation and identification of the different tattooed groups at the slaughterers' yards were impossible in a study involving commercial operations such as these.

As stated before in this study, a large portion of the hogs cooperatively shipped from Ohio direct to the packers is sold on the basis of yield. Cooperative association managers in the State have, on the whole, been very careful in grading their direct hogs in order to have them "dress-out" to the guaranteed yield or even return a bonus in the form of overdress. Even though these managers did grade their hogs as closely as possible, they were disappointed many times in having shipments underdress when it was reasonably certain that the hogs would yield more than the guarantee.

In checking on this phase of the study, it was found that grading alone was not the answer to high- or low-yielding hogs. In fact, those connected with the grading process were somewhat surprised at the differences in yield. Many expected to be able to grade out the high- and low-yielding hogs with much regularity but were greatly mistaken in numerous instances. However, when the influence of grading on yield is considered in a large number of hogs, there does seem to be a rather definite relation. Table 4 shows that the trend in the average yield of all hogs falling into the various grades is upward as the grade becomes higher. However, the same thing cannot be said for the different weight groups of hogs when considered on the same basis. Undoubtedly, many compensating errors have entered in, from the grading standpoint, that would have a tendency to make the average figures for the various grades seem to indicate a definite trend.

TABLE 4.—Influence of Grading on Yield in the Tattooed Sample

Weight group	Yield by grades				
	Fair	Fair to good	Good	Good to choice	Choice
180 lb. and under	74.8	75.3	75.1	75.5	75.7
181–200 lb.	74.2	74.6	74.9	75.8	75.6
201–220 lb.	74.3	74.3	75.2	74.0	75.5
221–240 lb.	75.3	.....	77.1	79.4	77.3
241 lb. and over	76.1	74.4	77.2	76.2	78.0
Average	74.5	74.7	75.3	75.9	76.1

The above analysis was carried one step farther to determine whether there was any variation among hogs having the same breeding and produced under the same conditions of feeding and management. Accordingly, an analysis was made on 258 hogs, each of which was tattooed a different number, after having been graded and made ready for shipment. At the time of tattooing, the individual liveweights of the hogs were noted, thereby making it possible to figure the individual yields of the hogs under consideration. Hogs from the various producers' lots were also identified, thus furnishing the opportunity for studying the variation in yield of hogs in the same lot, when production factors were constant.

In the frequency distribution that follows, the deviations in the yields of the individual hogs from group averages[14] were plotted and we find from Table 5 that the spread in the yields of hogs that have nearly the same breeding and are fed and managed exactly the same is surprisingly different.

TABLE 5.—The Deviations in the Yields of Individual Hogs from Each Group Average, in a Selected Sample of 258 Tattooed Hogs

Deviation from average	Frequency	
	No. hogs	Pct. of total
More than −6.75	11	4.3
−6.75 to −5.26	6	2.3
−5.25 to −3.76	7	2.7
−3.75 to −2.26	26	10.2
−2.25 to −0.76	45	17.4
−0.75 to +0.74	75	29.1
+0.75 to +2.24	46	17.8
+2.25 to +3.74	24	9.3
+3.75 to +5.24	8	3.1
+5.25 to +6.74	5	1.9
More than +6.74	5	1.9

When a similar comparison is run on the various grades of hogs in the same group, it is interesting to note that hogs of the same grade and produced under the same conditions vary in yield just as widely as do those in the same group when no importance is

[14]The following example may make the method used here more easily understood. One farmer delivers five hogs weighing, respectively, 180, 185, 190, 175, and 182 pounds; these hogs were tattooed different numbers as F-1, F-2, F-3, F-4, and F-5; the slaughterer also returned the individual carcass weights for each hog by tattooed number; then individual hog yields were calculated. For the five hogs these may be assumed to be as follows: F-1, 76.5%; F-2, 78.0%; F-3, 74.0%; F-4, 75.0%; and F-5, 75.5%. The average yield for these five hogs was then computed to be 75.8%, and a frequency table was constructed from this group average. The F-1 hog with a yield of 76.5% or 0.7% above the group average (76.5 less 75.8 equals 0.7%) would fall in the class interval of plus 0.75% to minus 0.75%. The F-2 hog with a yield of 78%, or 2.2% above the group average, would fall in the class interval of plus .76% to a plus of 2.25%. The F-3 hog with a yield of 74.0%, or 1.8% minus the group average, would fall in the class interval of a minus .76% to a minus 2.25%. Each of the remaining hogs was then classified from a group average for each farmer who delivered hogs in this analysis of 258 hogs.

attached to grade, Figure 1. In other words, according to this analysis, individual hogs belonging to the same farmer and graded as "choice" varied in yield as much as 19.0 points; "good" hogs as

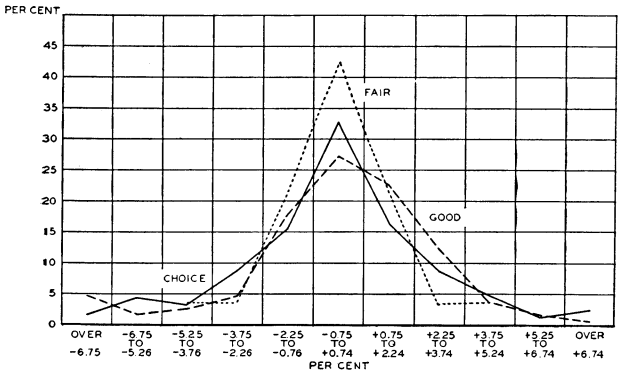

Fig. 1.—The deviations in the yields of individual hogs, by grades, from each group average in a selected sample of 258 tattooed hogs

much as 15.4 points; and "fair" hogs as much as 10.1 points, Table 6. The low average yield of one farmer's hogs in the "fair" grade varied as much as 11.7 points from the high average yield of the "fair" grade (70.6 per cent to 82.3 per cent). For the "good" grade, the spread was 11.4 points (72.7 per cent to 83.8 per cent), and for the "choice" grade, 6.4 points (75.4 per cent to 81.8 per cent). When the spread in yield of all hogs falling in the various grades is determined, the above figures become even greater.

TABLE 6.—The Average Yield and Spread in Yield for Each Group, by Grades, in a Selected Sample of 258 Tattooed Hogs

Group number	Fair			Good			Choice		
	No. hogs	Av. yield	Spread in yield	No. hogs	Av. yield	Spread in yield	No. hogs	Av. yield	Spread in yield
1	8	78.8	10.1	19	79.2	13.0	13	81.0	9.0
2	3	81.3	1.8	8	81.7	3.7	2	81.8	0.9
3	.....	.....	.....	15	77.8	15.4	30	78.0	14.3
4	1	70.6	.....	22	77.6	13.4	25	78.1	13.7
5	3	74.6	3.5	13	76.9	14.9	11	75.4	8.5
6	1	81.2	.....	4	80.4	2.6	5	81.7	12.4
7	1	82.3	.....	5	80.6	5.4	3	75.7	11.6
8	3	74.3	1.2	7	72.4	11.2	6	75.6	19.0
9	4	77.5	5.1	4	79.0	3.2	3	78.7	3.8
10	.....	.....	.....	1	83.8	.....	3	80.2	4.6
11	2	80.0	2.8	5	77.9	5.3	6	78.4	7.5
12	.....	.....	.....	.....	.....	.....	4	78.9	5.4
13	1	74.0	.....	1	74.7	.....	5	79.1	11.0
14	1	78.9	.....	3	78.7	4.8	7	80.4	8.4
Total and average	28	77.8	11.7	107	78.2	11.4	123	78.4	6.4

It must be kept in mind that part of the spread in this analysis of individual tattooed hogs is due to variation in both carcass weights and liveweights. The liveweights were obtained on ordinary livestock scales. These scales had a 5-pound break so that all weights in between the 5-pound limit had to be interpolated. Also, it was impossible for some carcasses to be perfectly identified; thus allowing errors to creep in. However, all doubtful data were thrown out before the analysis was made.

Having presented the analysis of yield by tattooed, farmer-owned groups of hogs, the next comparison of data will be concerned with the factors involved after the hogs had been assembled in the railroad cars. These factors will apply to the entire carload. For the basis of this analysis records were used from 437 carloads.[15]

Information was obtained on the yield by carload, the days intervening between the date of shipment and slaughter, the days in transit, the weight at time of shipment and time of delivery at the slaughtering plants. From these data the amount of shrink and the average carload weight per hog were calculated. Table 7 gives a summary for each month of the 437 carloads. An examination of the table reveals a very definite seasonal swing in yield. January was high, followed by a decline in February and March; then there was a slight rise in April, followed by a decline during May and

TABLE 7.—The Monthly Average Yield, Days in Transit, Days Until Slaughtered, Carload Shrink, and Weight; Also the Monthly Standard Deviation of Yield and Shrink for 437 Carloads Sold Direct to One Slaughterer for the Year 1930

Month	Number of carloads	Monthly average					Standard deviation	
		Yield	Days in transit	Days until slaughtered	Carload shrink	Carload weight per hog	Yield	Shrink
January	17	76.13	3.0	4.3	7.07	196	1.29	1.02
February	10	75.70	3.0	3.6	7.87	190	1.55	.69
March	25	75.46	2.9	4.1	9.08	187	1.54	1.75
April	22	75.63	2.9	4.4	9.40	188	1.47	1.77
May	36	74.86	3.2	4.6	9.53	188	1.35	1.32
June	38	74.09	3.0	5.4	9.76	188	1.31	1.21
July	35	75.05	3.7	4.7	8.96	189	1.64	2.23
August	38	73.97	2.9	4.4	10.43	184	1.39	2.44
September	57	73.51	3.0	5.9	10.31	186	1.56	1.63
October	63	73.85	3.1	4.7	9.94	187	1.34	1.56
November	60	74.28	3.0	4.8	9.28	190	1.11	1.68
December	36	75.79	3.0	3.8	8.33	189	1.32	1.40

[15]These data were obtained from records of the National Order Buying Company, Columbus, Ohio. The records were limited to one slaughterer, in order to obtain more uniformity in the records and less need of adjustment; for example, the method of weighing carcasses with heads off or on, kidneys in or out, etc., would be uniform. Also, the hogs purchased by this particular slaughterer were of a fairly uniform weight and quality, more so at least than hogs purchased by many of the other slaughterers.

June. In July the yield increased nearly a point over June; but in August it dropped under June and made the seasonal low in September. From the low in September the yield increased rather abruptly during the fall months. At this point it is interesting to turn back to Figure 4, Section (A) and observe how the yield of hogs slaughtered under Federal Inspection varied during this same period.

Examination shows that Federal Slaughter followed, in general, the same course from month to month during 1930, as the average of the 437 carloads.

Upon closer analysis, carload shrink[16] was found to have an inverse correlation to yield, Figure 2; the same is true for the days intervening between the time of shipment and the time of slaughter. Weight followed to some extent a more direct relation to yield. Thus, from the standpoint of seasonal influence, several factors are shown to have a bearing on yields. The two right-hand

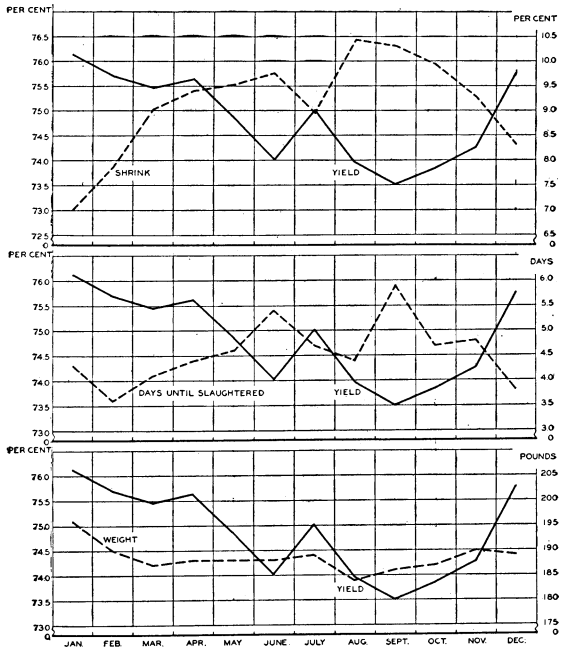

Fig. 2.—The yield, carload shrink, days until slaughtered, and liveweight, averaged by months, for 437 carloads of hogs sold direct to one slaughterer for the year 1930.

[16]Shrink in this study is understood to mean the difference in the weight of hogs at time of shipment and at time of unloading from the railroad cars at the slaughterer.

columns in Table 7 give the standard deviation of yield and shrink for each month; that is, the standard deviation of yield for each month was calculated from the mean of the yield for that month. The same holds true for shrink.

For yield, the standard deviation was about the same for each month during the year, which means that the dispersion of different carloads about the mean of each month was nearly the same for each of 12 months.

The standard deviation for shrink was not nearly as uniform. It was smallest during January and February and then widened out in March and April, narrowed during May and June, and reached the widest point for the year in July and August. From this point it narrowed during the 4 autumn months.

This analysis would show that, while shrinks were related to yield, it was possible to have high-shrinking hogs with the yield varying but little. Stated in another way, shrink influenced yield but did not influence it in the same ratio.

Up to this point the analysis of the carload data has been approached only from the standpoint of monthly averages. In the next few pages each of the factors has been analyzed separately.

Shrink was found to have the greatest influence on yield. When the data were arranged in a frequency distribution, Table 8, it was found that shrink had an inverse relation which was rather significant. This table also points out that there was considerable spread in shrink over a large number of carloads. It was not uncommon for a carload of hogs to arrive at the slaughtering plant with a shrink of between 6 and 12 per cent; indeed, 15 of the 437 carloads had less than 6 per cent shrink, while 30 had more than 12 per cent.

TABLE 8.—Variation in the Average Carload Yield for Groups with Various Shrinks for 437 Carloads

Carload shrink Per cent	Carloads		Carload average yield Per cent
	Number	Per cent	
Under 6.00	15	3.4	76.49
6.00-6.99	16	3.7	76.48
7.00-7.99	57	13.1	75.30
8.00- 8.99	93	21.3	74.99
9.00- 9.99	100	22.9	74.38
10.00-10.99	84	19.2	73.96
11.00-11.99	42	9.6	73.71
12.00-12.99	18	4.1	72.81
13.00-over	12	2.7	73.38
	437	100.0	

The analysis of 437 carloads showed that when the shrink was 12 per cent or more, the yield declined to around 73 per cent. On the other hand, when the shrink was light (that is, less than 7 per cent), the yield averaged more than 75 per cent. It should be pointed out here that not every high-shrinking carload was low yielding and every low-shrinking carload was high yielding. In fact, many carloads were just the opposite.[17] This is emphasized by the coefficient of correlation. When shrink and yield were correlated, the corrected coefficient of correlation was —.562, showing that many observations varied greatly from the average relationship.

Another factor which influenced yield, as shown in Table 7, was the number of days intervening between the time of shipment and the time of slaughter. Although the days in transit for the 437 carloads averaged about the same for each of the 12 months, the days intervening until slaughter showed an inverse relation to yield. This is further emphasized in Table 9. For many reasons, hogs cannot be slaughtered the same day they arrive at the packing plant. These reasons need not be enumerated here, but the holding of hogs for an excessive length of time in the yards at the packing plants had an effect on the yield. Table 9 points out that 12.6 per cent of the carloads were slaughtered from 3 to 4 days after they were shipped. Most of the carloads were held from 4 to 5 days; whereas 7.1 per cent of the cars was not slaughtered until 7 or more days after shipment. Only three carloads were kept more than 7 days. The table emphasizes the fact that when hogs were held much longer than 4 days from the time of shipment to the time of slaughter, the yield showed a lower average. There was little difference between 3 and 4 days, but the yield declined rapidly when the hogs were slaughtered 6 or 7 days after shipment.

TABLE 9.—The Average Carload Yield, by Length of Time Intervening from Shipment to Time of Slaughter for 437 Carloads

Days until slaughtered	Carloads		Average carload yield
	Number	Per cent	
3-3.9	55	12.6	75.12
4-4.9	164	37.5	75.11
5-5.9	106	24.3	74.39
6-6.9	81	18.5	73.69
7-over	31	7.1	73.32
	437	100.0	

[17]This was visibly demonstrated by a scatter diagram of yield and shrink.

When this factor was correlated with yield, the adjusted coefficient of correlation obtained was —.351, thus showing that delay in slaughtering has an influence on yield. However, there are many other important influences that must be considered.

Referring again to Table 7, the average weight per hog per carload was rather uniform throughout the 437 carloads. However, some carloads averaged slightly over 200 and some under 180. An analysis of the basis of weight would not be expected to show much relation between weight and yield, Table 10, for this factor was partially eliminated in selecting the 437 carloads sent to one slaughterer; in the case of the group weighing over 200 pounds, the yield was somewhat higher than for the lighter-weight groups.

TABLE 10.—The Average Carload Yield for Different Weight Groups for 437 Carloads

Average carload weight	Carloads		Average carload yield
	Number	Per cent	
Under 180	33	7.6	74.74
180–189	223	51.0	74.43
190–199	158	36.1	74.51
200–over	23	5.3	75.45
	437	100.0	

The influence of weight on yield is further shown in this study by the analysis of the hogs tattooed. The data were divided into two groups. One contained those hogs weighing 200 pounds and less, while the other group contained the ones averaging over 200 pounds. These two groups showed a total weight of over 2,500,000 pounds. The resulting frequency distribution, according to the yield of these two groups, is presented in Figure 3. It is at once observed that the yield was higher on the group containing the heavy hogs. The modal group of the heavy hogs was from 77 per cent to 78 per cent, and for the light group was 75 per cent to 76 per cent. As a result it is clear that, while there may be exceptions, on the average heavier hogs may be expected to yield higher.

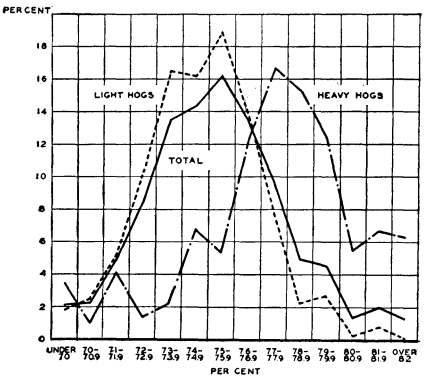

Fig. 3.—Distribution of yield by light and heavy hogs for each individual farmer having hogs in the tattooed sample.

Where hogs vary in weight by several hundred pounds, weight does have a very definite influence on yield. This is pointed out in a summarization of the yield of fat barrows slaughtered at the International Livestock Exposition. (Table 11.) While there was considerable spread from the low- to the high-yielding group, yet the increase was not uniform. The groups averaging from under 200 to 251-300 pounds showed little difference in yield. This is the same result observed in the monthly averages of hogs slaughtered under Federal Inspection.

TABLE 11.—The Yield of Show Hogs by Different Liveweight Groups at International Livestock Exposition, 1906-1908, 1910-1913, 1916-1925*

Liveweight	Hogs	Average		
		Liveweight	Cold weight	Yield
Lb.	*No.*	*Lb.*	*Lb.*	*Pct.*
200-under	9	568	470	82.74
201-250	42	3061	2485	81.18
251-300	27	2469	2046	82.86
301-350	24	2544	2158	84.82
351-over	51	7055	5962	84.51

*Source: *Crops and Markets*, U. S. Department of Agriculture.

The heavier weight groups, those above 300 pounds, indicated a much higher yield. Since most of these hogs were fed by very skillful feeders, most of the carcasses would be more uniform in quality and finish than those of the day-to-day purchases of hogs going to our packing plants. As a result, weight should show more influence on yield, and yet the differences are negligible in the weight groups under 300 pounds.

These factors which have just been discussed—shrink, days intervening between time of shipment and time of slaughter, and average weight—were measured mathematically by means of multiple correlation. In order to simplify the amount of calculation, only part of the 437 carloads was used. It was decided to multiple-correlate only those loads which had been tattooed. Of the 437 carloads, 80 were tattooed. To that 80 marketed to one packer, it was decided to add 20 other tattooed loads marketed to other packers, making 100 in all. The last 20 carloads averaged much heavier and were slaughtered by several additional packers. The data were adjusted for differences in records so that they were comparable. The check sum method of multiple correlation was used and yield was correlated with shrink, average weight, days intervening between time of shipment and time of slaughter, and month of shipment. These four independent variables were used. It was

thought best to add the seasonal influence to the correlation since it was probable that not all of the seasonal influence was accounted for by the other variables. The result of this procedure gave us a coefficient of multiple correlation of .695 after it had been adjusted for the number of cases. The coefficient of multiple determination was then found to be 48.2 per cent. Thus, as a result of combining the above influences and measuring the effect on yield, it showed statistically that 48.2 per cent of the fluctuation in yield was due to the variables enumerated above, thus leaving the balance to other causes.

FEDERAL INSPECTED SLAUGHTER

At this point it is interesting to compare and observe how yield varies for hogs slaughtered under Federal Inspection. The United States Department of Agriculture obtains monthly from packers slaughtering under Federal Inspection information on the average liveweight, average dressed weight, percentage of lard rendered per hundredweight of carcass, the percentage of barrows slaughtered, and other information. These data are published monthly in *Crops and Markets* by the United States Department of Agriculture. From the average liveweight and dressed weight, the dressing percentage or yield can be obtained. Thus, one can ascertain how the yield of Federal Inspected Slaughter varies over a period of time and how it is related to other factors. The data available for this part of the analysis were complete for the years starting with January 1, 1923; therefore, the 8 years from 1923 to 1930 only have been analyzed in this study.

The yield of Federal Inspected Slaughter for the 8 years 1923 to 1930 is presented in Figure 4. Upon examining this graph closely, important variations are observed. First of all, there is a considerable variation from month to month, and, upon further examination, there appears a variation from year to year. The years 1926 and 1927 have given rather high yields and 1924 low yields. The yield for the 12 months of 1926 and 1927 averaged 76.4 per cent and 76.1 per cent, respectively, while for 1924 the yield dropped to 75.2 per cent for the 12-month period.

A very definite seasonal trend in the yield was found for the 8 years and is shown graphically in Figure 5. While this seasonal fluctuation was relatively small, it was definite. The low point for the season occurred in the fall months, usually September or October; whereas the high point arrived during the late autumn and winter months.

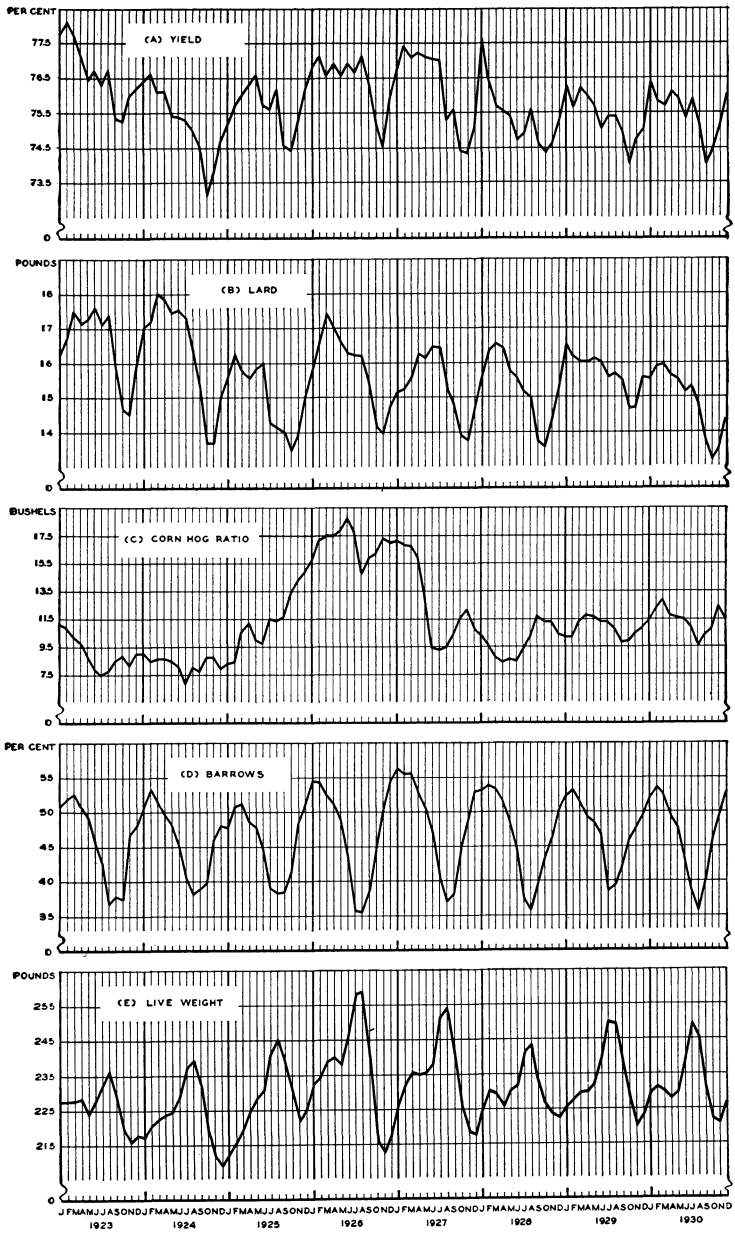

Fig. 4.—The yield of hogs, lard produced per hundredweight, the percentage of barrows and liveweight of hogs slaughtered under Federal Inspection, and the corn-hog ratio for the United States, averaged by months for the years 1923-1930.

This average seasonal variation shows that the yield of hogs can be expected to vary around two points, from the high point of the winter months to the low point in the autumn. The high yield of the year, on the average, came in January, followed, with one exception, by a steady decline to the low point in October. From the low point it rose rapidly to the seasonal high point again in January.

While this seasonal fluctuation was relatively small, yet it is important. As an example of this variation let us take a 200-pound hog, liveweight, costing 10 cents per pound. Should this hog be slaughtered in January, it would be expected to yield about 76.5 per cent, as an average for the 8 years 1923 to 1930. This would mean a dressed cost of $13.07 per hundredweight. Should a similar hog of 200 pounds be slaughtered in October, it would be expected to yield around 74.5 per cent, on the basis of the 8-year average. At 10 cents liveweight, this would make a dressed cost of $13.42 per hundredweight, or thirty-five cents more per hundredweight ($13.42—$13.07 = $0.35). This difference in dressed cost translated to liveweight terms would mean that the hog slaughtered in October would be worth about 26 cents less per hundred pounds liveweight than the hog slaughtered in January. This emphasizes the fact that the liveweight price may be expected to be lower during the autumn months than at other seasons of the year.

Since this variation exists both seasonally and from year to year, the question of influencing factors was raised. It was assumed that some of the more important of these factors influencing yield would be weight, feeding conditions, the proportion of barrows to sows slaughtered, the amount of lard produced, the days intervening between the time of shipment and slaughter, and the amount of shrink.

Not all of this information was available over a period of years for Federal Inspected hogs. Data on liveweight, lard produced per hundredweight, and the percentage of barrows slaughtered were obtained from *Crops and Markets*. As a factor representing feeding conditions, it was decided to use the corn-hog ratio for the United States. Since the corn-hog ratio indicates the cheapness of corn in relation to the price of hogs and since hogs fed on corn are more desirable in the meat trade than those given some other feeds, it was assumed there might be a relation between yield and the corn-hog ratio. The other factors mentioned were not available for Federal Inspected Slaughter.

The factors available were next examined and compared with yield. The actual data are presented graphically in Figure 4. In order to test the relationship mathematically, simple correlation was used after some preliminary analysis. When the data for the 8 years were correlated, some relationship was found. Table 12.

TABLE 12.—The Correlation of Yield of Hogs Slaughtered Under Federal Inspection with the Percentage of Lard, Percentage of Barrows Slaughtered, Liveweight, and the Corn-hog Ratio for the United States for the Years 1923-1930

(Check sum method used)

Yield correlated with	Unadjusted coefficient of correlation	Coefficient of determination
		Pct.
Lard	0.621	38.62
Corn-hog Ratio	0.478	22.84
Barrows	0.407	16.56
Liveweight	0.229	5.24

Yield and lard gave the highest correlation of the four factors analyzed and, likewise, the highest coefficient of determination.[18] The corn-hog ratio was next to lard, followed by the percentage of barrows slaughtered, with weight showing little or no influence.

In correlating yield with the corn-hog ratio, a lead of 2 months, which gave the highest correlation, was given to the corn-hog ratio. Stated in another way, the corn-hog ratio for January was correlated with the yield 2 months later (that of March), and so on for the 8-year period.

The data were then analyzed for seasonal influences. An 8-year arithmetic monthly average was computed. Figure 5 presents these actual monthly averages.

An analysis of Figure 5 reveals very definite seasonal variation in all of the factors. Lard follows very closely the same seasonal variation as yield, except for some difference in January and February. The percentage of barrows slaughtered was similar to the yield, although the low point in that curve came 2 months before

[18]For those not familiar with the meaning of correlation, the following may aid in understanding its meaning. When yield is compared with the amount of lard obtained from a carcass, some relationship is found in these factors. Stated in another way, the more lard obtained, the higher the yield. One of the measures of such relationship used by statisticians is called the coefficient of correlation and can be computed mathematically. Another measure which is also useful is known as the coefficient of determination. This is obtained as follows: If the coefficient of correlation of yield and lard is found to be .6, then this is squared ($.6 \times .6 = .36$) and then multiplied by 100 in order to change to a percentage basis ($.36 \times 100 = 36.0\%$). This per cent figure is the per cent of determining influence on yield, which can be attributed to the amount of lard obtained from the carcass of a hog. Stated in another way, when the coefficient of correlation between yield and lard is found to be .6 and the coefficient of determination 36.0 per cent, it means that the amount of lard obtained only accounts statistically for 36 per cent of the variation in yield. The remaining 64 per cent ($100 - 36 = 64$) of the variation of yield is due to other factors. For further explanation see *Methods of Correlation Analysis* by Ezekiel.

the low point in the yield curve. The corn-hog ratio seasonal curve was very similar to the curve of barrows slaughtered, except in March and December. Liveweight showed the biggest seasonal variation from yield of any of the factors. Indeed, it was almost the opposite of the yield curve.

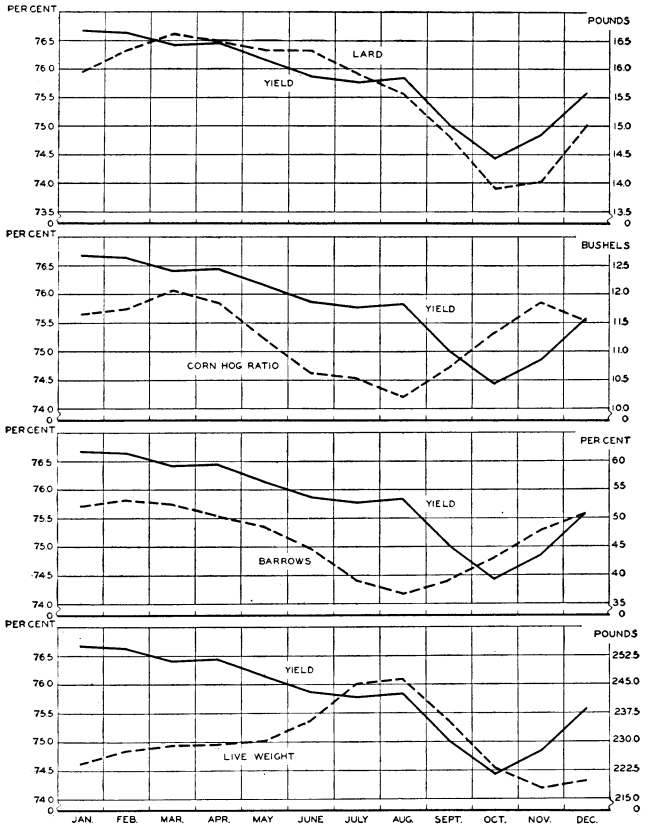

Fig. 5.—Seasonal variation in yield of hogs, lard produced per hundredweight, percentage of barrows and liveweight for hogs slaughtered under Federal Inspection, and the corn-hog ratio for the United States, averaged for the years 1923-1930.

In order to compare statistically the year to year swings, seasonal influence was removed. This was done by computing an index of seasonal variation (Table 13), obtained from the 8-year arithmetic monthly averages. After removing the seasonal variation,

the data were smoothed for accidental variations with a 9-month moving average.[19] This statistical procedure brings out the cyclical swings during the period or the variation between years.

TABLE 13.—The Index of Seasonal Variation for the Percentage of Barrows Slaughtered, U. S. Corn-hog Ratio, Lard per 100 Pounds of Liveweight, the Average Liveweight, and the Yield of Hogs Slaughtered Under Federal Inspection for the 8 Years 1923 to 1930

Month	Barrows slaughtered	Corn-hog ratio	Lard	Average liveweight	Yield
January	112.05	103.30	102.13	97.43	101.15
February	114.27	103.96	104.56	98.79	101.09
March	112.77	106.84	106.36	99.48	100.79
April	108.11	105.07	105.60	99.63	100.83
May	104.38	99.53	104.67	99.95	100.47
June	96.46	94.32	104.58	102.15	100.10
July	83.90	93.43	101.91	106.38	99.96
August	79.40	90.55	99.76	106.98	100.04
September	84.04	94.98	94.84	102.15	98.95
October	92.30	100.42	89.03	96.98	98.18
November	103.01	105.18	89.88	94.62	98.73
December	109.31	102.41	96.65	95.46	99.71
Average	100.00	100.00	100.00	100.00	100.00

The resulting data are presented in Figure 6. Very definite swings are shown in yield, lard, percentage of barrows slaughtered, corn-hog ratio, and liveweight.

These data were multiple-correlated by the check sum method. Corn-hog ratio was given a lead of 2 months. As a result of this method of statistical analysis a coefficient of multiple correlation of .895 was obtained, after being adjusted for the number of cases. This gave a coefficient of multiple determination of 80.1 per cent. This means statistically that the four factors correlated with yield account for 80.1 per cent of the influence of the variation in yield from year to year. Thus, the four factors—the amount of lard received per 100 pounds of liveweight, the percentage of barrows slaughtered, the corn-hog ratio, and the average liveweight—would definitely seem to influence the yield of hogs over an 8-year period. Although these factors account for much of the variation, yet it is definitely shown there remain other influencing variables working upon yield.

[19]To obtain a 9-month moving average (May for example), the items or values for the 4 months preceding May (January, February, March, and April) and the 4 months following May (June, July, August, and September) are added to the value of May. This sum represents the total for 9 months and is divided by nine, giving a 9-month average. For June the values for the 4 preceding and 4 following months are added to June and divided by nine. Thus, each month is used nine times. This average smooths out the fluctuations from month to month, giving a better indication of trend.

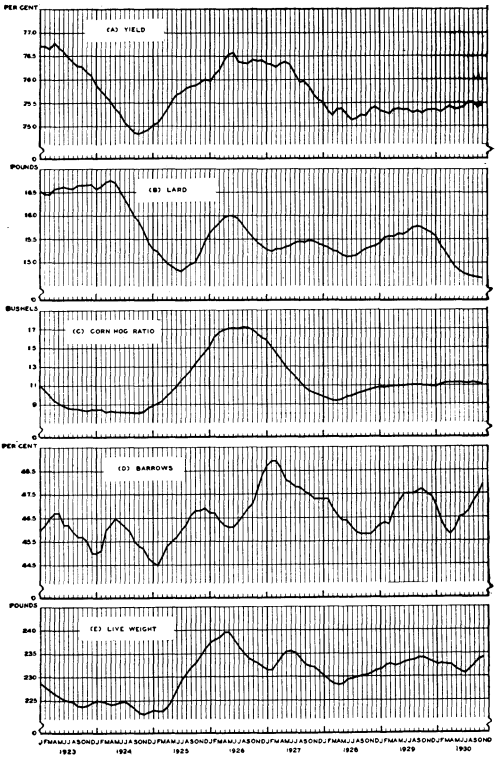

Fig. 6.—Nine-month moving average in seasonal variation removed of the yield of hogs, lard produced per hundredweight, the percentage of barrows and liveweight of hogs slaughtered under Federal Inspection, and the corn-hog ratio for the United States for the years 1923-1930.

COMBINING ALL FACTORS WHICH SEEM TO INFLUENCE YIELD

From the earlier analysis of this study it was shown that production factors had but little influence on yield. An examination of the marketing factors showed that shrink and yield had an inverse relation, that the same was true for the number of days intervening from time of shipment until time of slaughter, that liveweight affected yield but slightly, and that yield had a distinct seasonal variation throughout the 12 months. However, these factors only accounted for part of the determining influences on yield.

In the analysis of Federal Inspected Slaughter none of the above-mentioned influences were considered, except the seasonal factor and liveweight. The seasonal influence was removed from the data on Federal Slaughter by the statistical method—the index of seasonal variation. When the Federal Slaughter data were analyzed over an 8-year period, with seasonal influence removed and the data smoothed with a 9-month moving average, it was found that the percentage of lard, the percentage of barrows slaughtered, and the corn-hog ratio had considerable influence on the cyclical swings in the yield of hogs slaughtered under Federal Inspection.

The question then arises as to how all these influences combined would affect yield, as in the case of the slaughtering of hogs. The data on tattooed hogs failed to furnish the percentage of lard or the percentage of barrows slaughtered; hence, this information was not available except for Federal Slaughter, for each of the 12 months of 1930. Shrink was available only from carload data. It was not possible, due to the nature of the study, to secure this information on the separate tattooed lots of hogs.

The percentage of barrows in each tattooed group could have been obtained had we considered this factor important at the time of starting the study. Shrink could not have been obtained easily for each of the tattooed lots; the same was true of lard. From the data described above, it was decided to try to combine all these factors and to measure statistically their influence on yield.

Since the data on Federal Slaughter are available monthly, the method used was as follows: Data on the tattooed groups were averaged for each month of 1930; then the monthly averages of the tattooed data and Federal Slaughter were combined into a multiple-correlation analysis.

Since the average of the monthly yield of the 437 carloads followed that of the Federal Slaughter rather closely, it was thought that the monthly data on the tattooed hogs would also be typical in the case of the percentage of barrows slaughtered and of lard per hundred pounds of carcass.

Monthly averages were secured from the tattooed data on yield, hours off feed before shipment, shrink, days intervening between time of shipment and time of slaughter, and liveweight.

The monthly average on yield was then correlated with these factors, plus the factors available on Federal Slaughter—namely, the percentage of lard obtained per hundred pounds of carcass, the percentage of barrows slaughtered, the United States corn-hog ratio, and the seasonal influence. The check sum method of multiple correlation was used to correlate yield with the above-mentioned factors.

As a result of this statistical procedure, an adjusted coefficient of multiple correlation of .987 was obtained. This gave a coefficient of multiple determination of 97.4 per cent. Thus, when the data were averaged as described above, the factors accounted for 97.4 per cent of the variation. If this method could have been applied to data on the individual lots of tattooed hogs, it is extremely doubtful if any such high correlation would have been obtained. It is used here as a method of combining all those influencing factors which seem to cause yield to vary by carloads, regardless of whether they are from the same shipping point, the same farmers, or on the same day and month. However, it is the belief of the authors that the above mentioned are the major factors and the most important ones affecting the yield of hogs.

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